Renewable Energy Technologies: Progress, Markets, and Industries

2nd Renewable Energy Analysis Forum

May 29, 2002

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Operated for the U.S. Department of Energy by Midwest Research Institute • Battelle • Bechtel

Contents

- For each major renewable energy technology: cost trends, market growth, industry
  - wind
  - biomass
  - photovoltaics
  - other renewable electric
  - solar buildings
- Green Marketing
- Existing renewable energy power plants

Low Wind Speed Technology Development

WTC 500 kW Prototype
Mojave, CA

Enron Wind 1.5 MW Turbines
Indian Mesa, TX

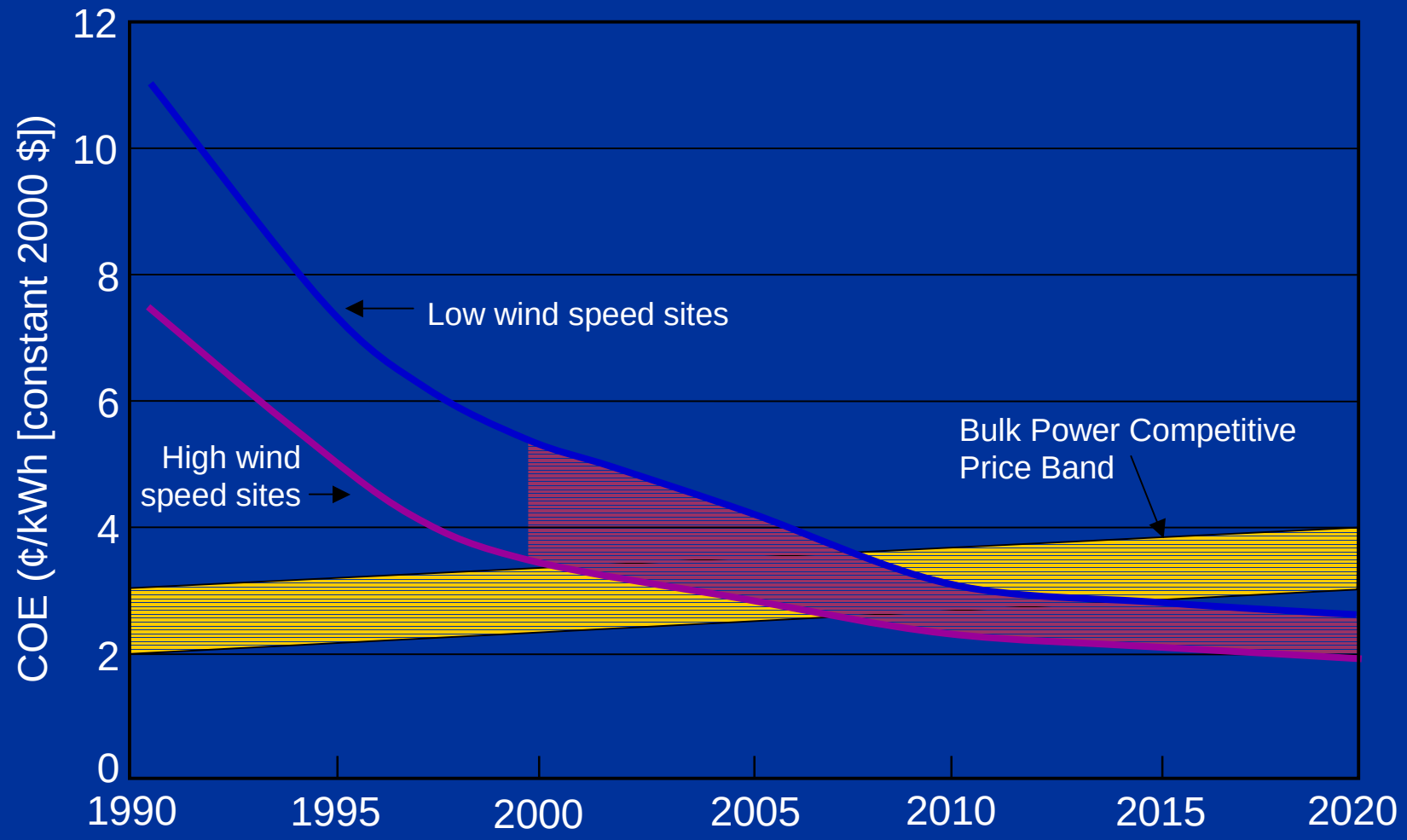
Current Status of Wind Technology:

- Wind Technology has matured over 25 Years
- Availability now reported at 98-99%
- Certification to international standards for new turbine designs helps avoid "major failures"
- Current designs produce electricity for 4-6 cents/kWh at Class 6 wind sites (15 mph or higher average wind)
- Variable speed power electronics mitigate some grid issues

Low Wind Speed Technology Innovations for the future:

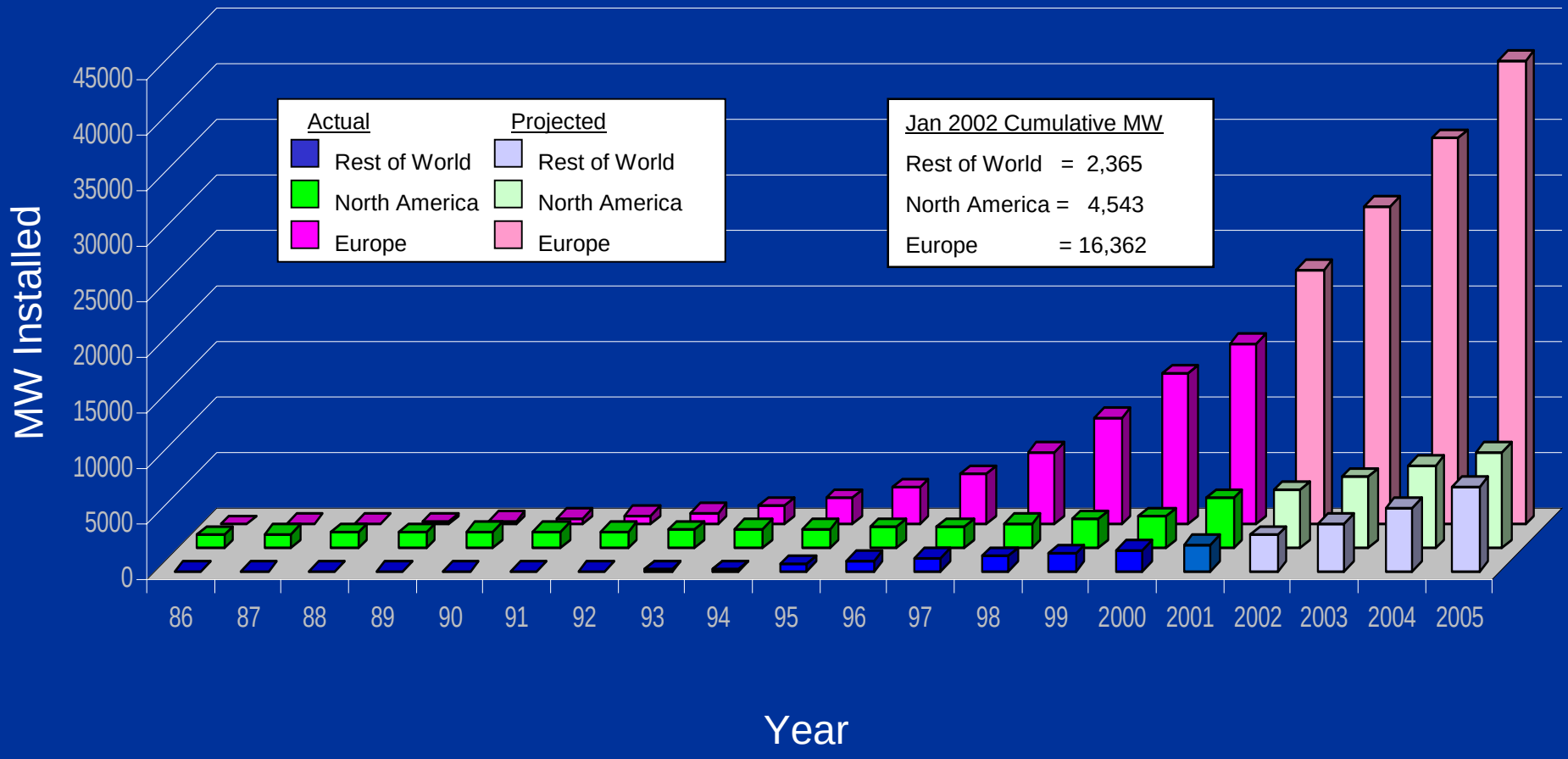
- Larger-scale 2 to 5 MW, with rotors diameters to 120 meters
- Flexible, thin high-speed rotors
- Extendable rotor concepts
- Hybrid glass-carbon rotors
- Load feedback control systems
- Custom designed low-speed, permanent-magnet generators
- Self-erecting tall tower designs, 85 to 100 meters tall
- Offshore wind turbines

Wind Cost of Energy



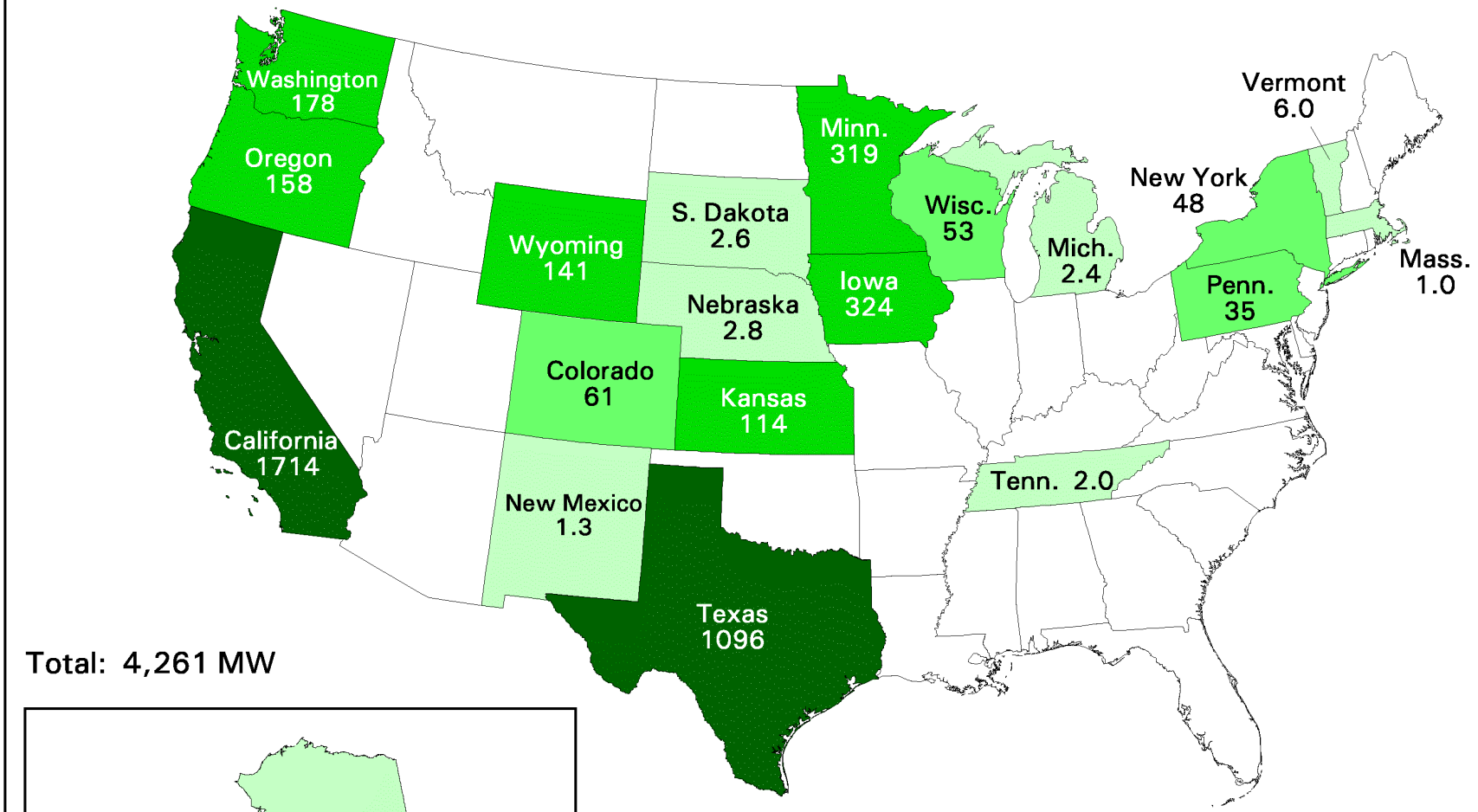
Source: DOE Wind Program

Growth of Wind Energy Capacity Worldwide

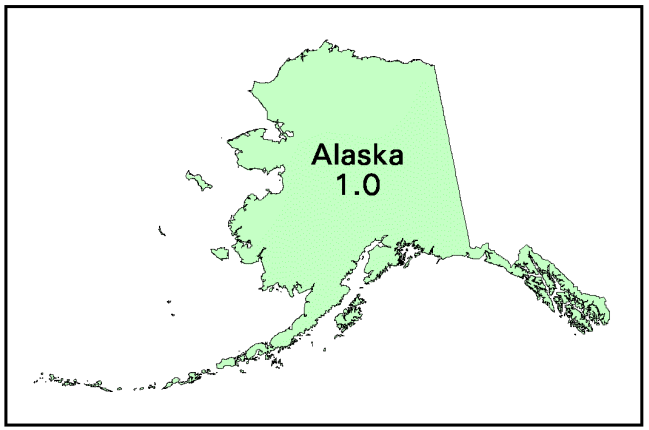


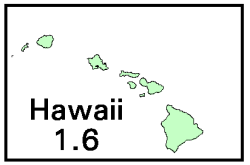
Sources: BTM Consult Aps, March 2001
Windpower Monthly, January 2002

United States - 2001 Year End Wind Power Capacity (MW)



Total: 4,261 MW





Wind Power Capacity
Megawatts (MW)

- 1,000 - 2,000
- 100 - 1,000
- 20 - 100
- 1 - 20

U.S. Department of Energy
National Renewable Energy Laboratory

NREL

28-JAN-2002 1.1.11

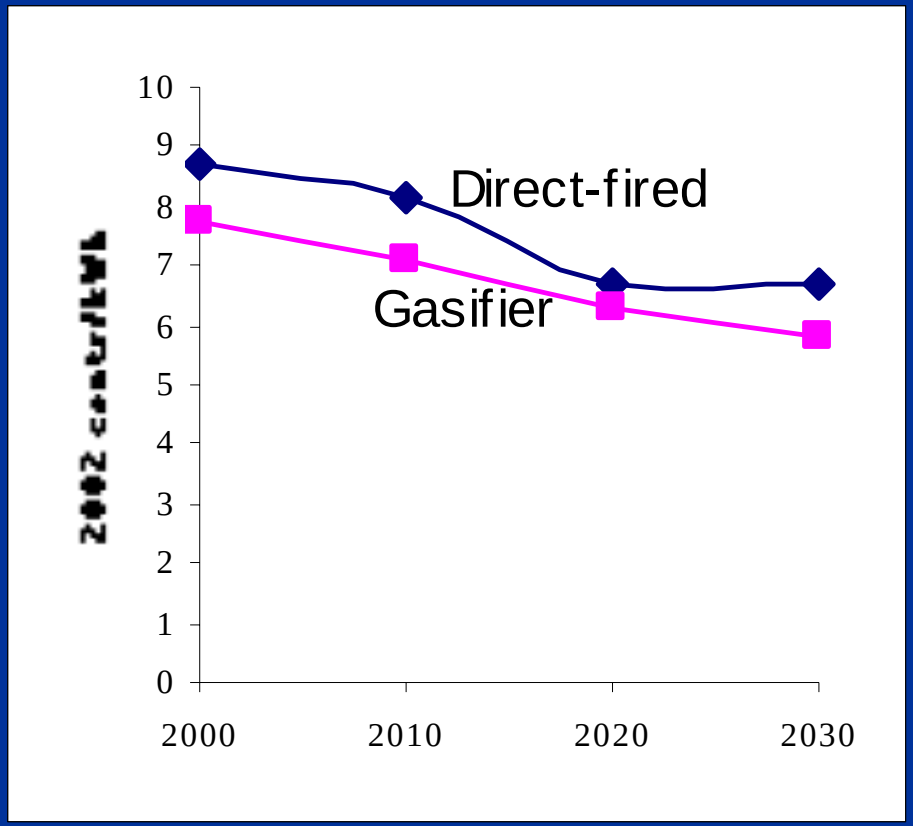
Finances and Incentives

- Production Tax Credit
  - 1.7 cents/kWh (escalating) for 10 years equates to around 1.1 cents/kWh reduction in contract price
  - Currently available for plants installed by 12/03 (deadline pressure *increases* costs)
  - 5 year extension being debated
- State and Local tax, etc. can be significant
  - +/- 0.5 cents/kWh impact
- Public Power (100% debt at tax free rates)
  - 60% of GenCo or IPP cents/kWh
  - Renewable Energy Production Incentive available, but annual appropriation leads to limited value when financing projects

Economic Development Opportunities

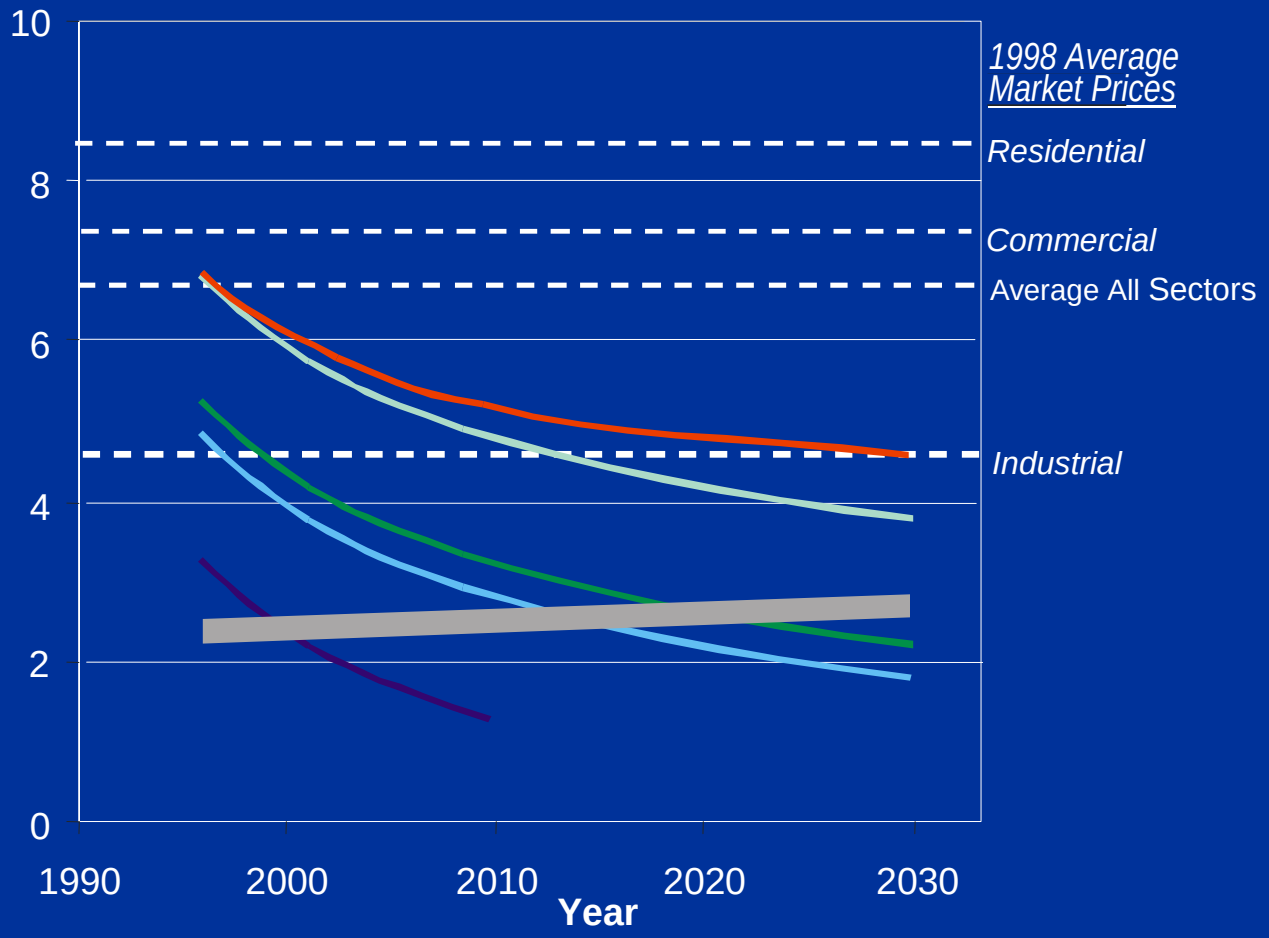
- Land Lease Payments: 2-3% of gross revenue $2500-4000/MW/year
- Local property tax revenue: 100 MW brings in on the order of $1 million/yr
- 1-2 jobs/MW during construction
- 2-5 permanent O&M jobs per 50-100 MW,
- Local construction and service industry: concrete, towers usually done locally
- Investment as Equity Owners: production tax credit, accelerated depreciation
- Manufacturing and Assembly plants expanding in U.S. (Micon in IL, LM Glasfiber in ND)

Biopower



Source: http://www.eren.doe.gov/power/techchar.html

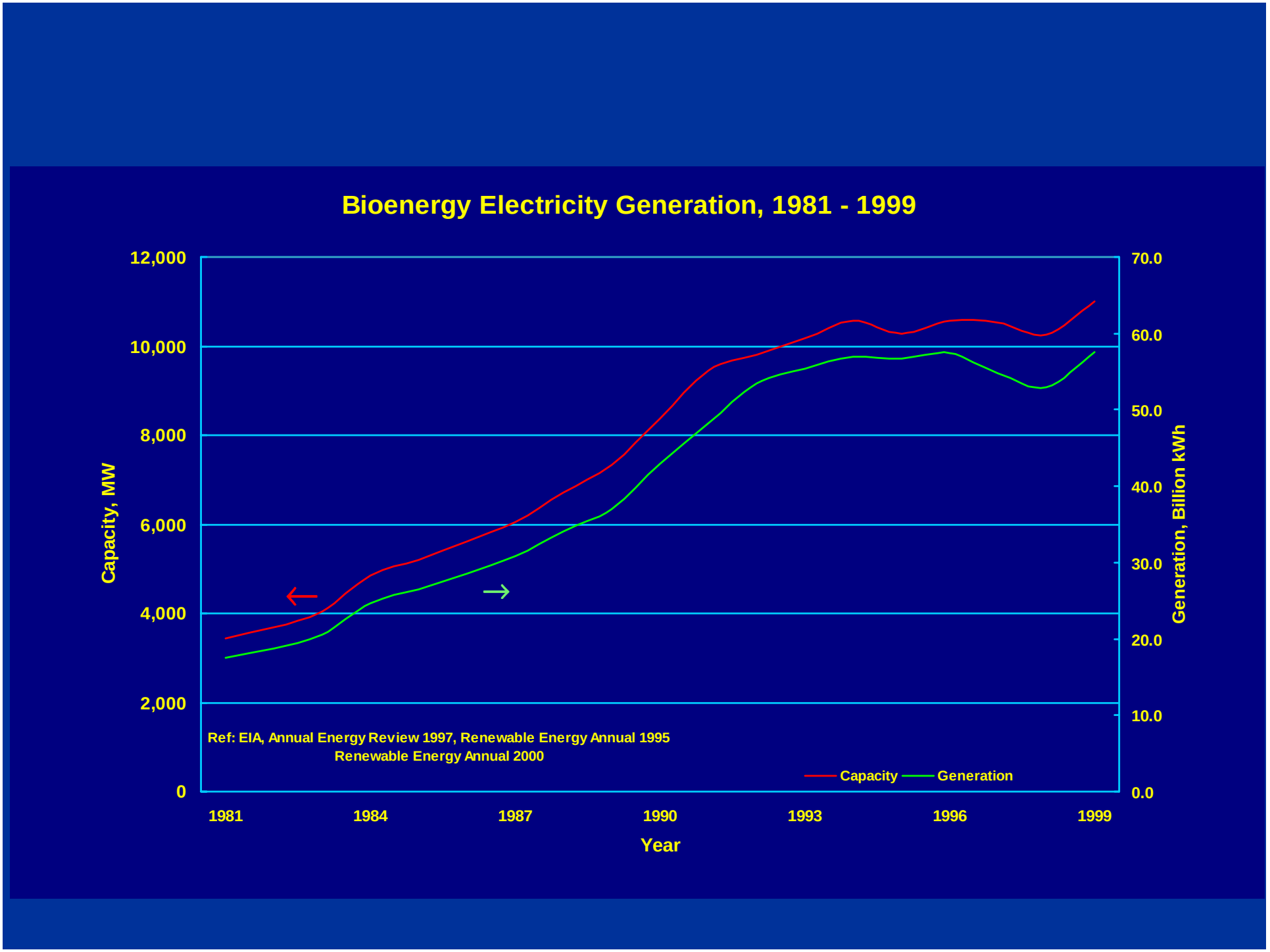
Projected Cost of Electricity from Biomass



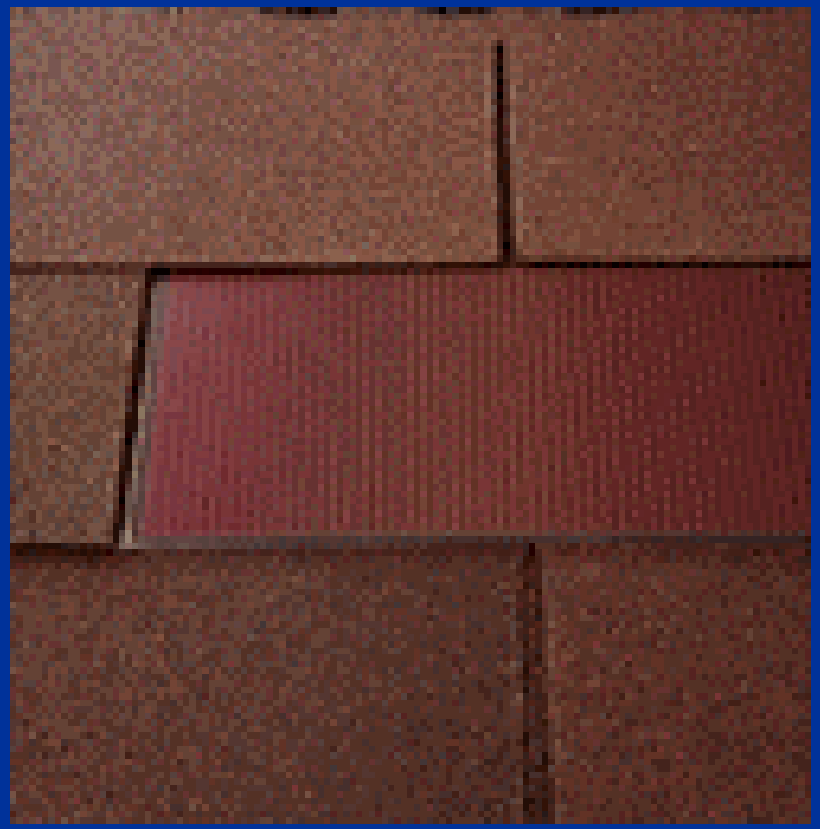
- Biomass Gasification Combined Cycle (BIGCC)
- Accelerated BIGCC / energy crops
- Accelerated BIGCC / energy crops / 1.5¢/kWh tax credit or co-product(s)
- Accelerated BIGCC / residues
- Accelerated BIGCC / residues / 1.5¢/kWh tax credit or co-product(s)
- New natural gas combined cycle

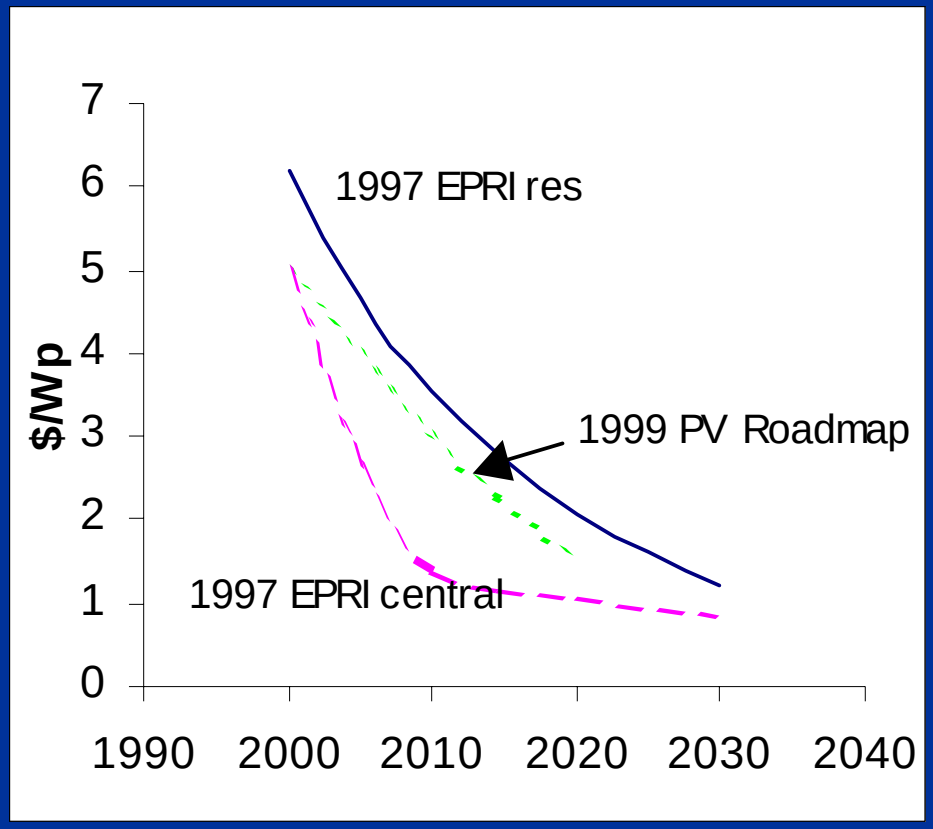
Notes
-Ranges on cost are 1 - 1.5¢/kWh due to financing assumptions (high = IPP; low = Muni)
- Assumes EIA fuel cost projections for natural gas

Source: www.eren.doe.gov/biopower


Bioenergy Electricity Generation, 1981 - 1999
12,000
10,000
8,000
6,000
4,000
2,000
0
Capacity, MW
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Generation, Billion kWh
1981
1984
1987
1990
1993
1996
1999
Year
Ref: EIA, Annual Energy Review 1997, Renewable Energy Annual 1995
Renewable Energy Annual 2000
Capacity
Generation

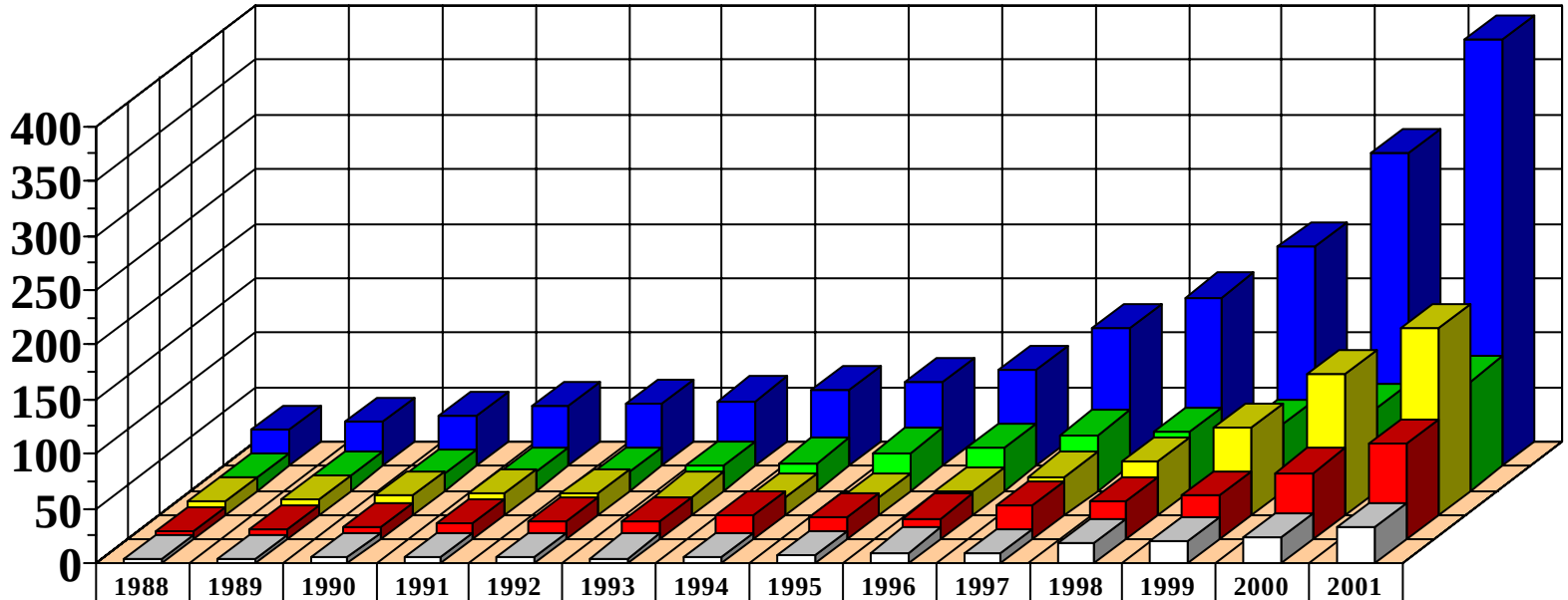
Photovoltaic Costs





Sources: http://www.eren.doe.gov/power/techchar.html
http://www.nrel.gov/ncpv/pvmenu.cgi?site+ncpv&idx=3&body=pvplans.html

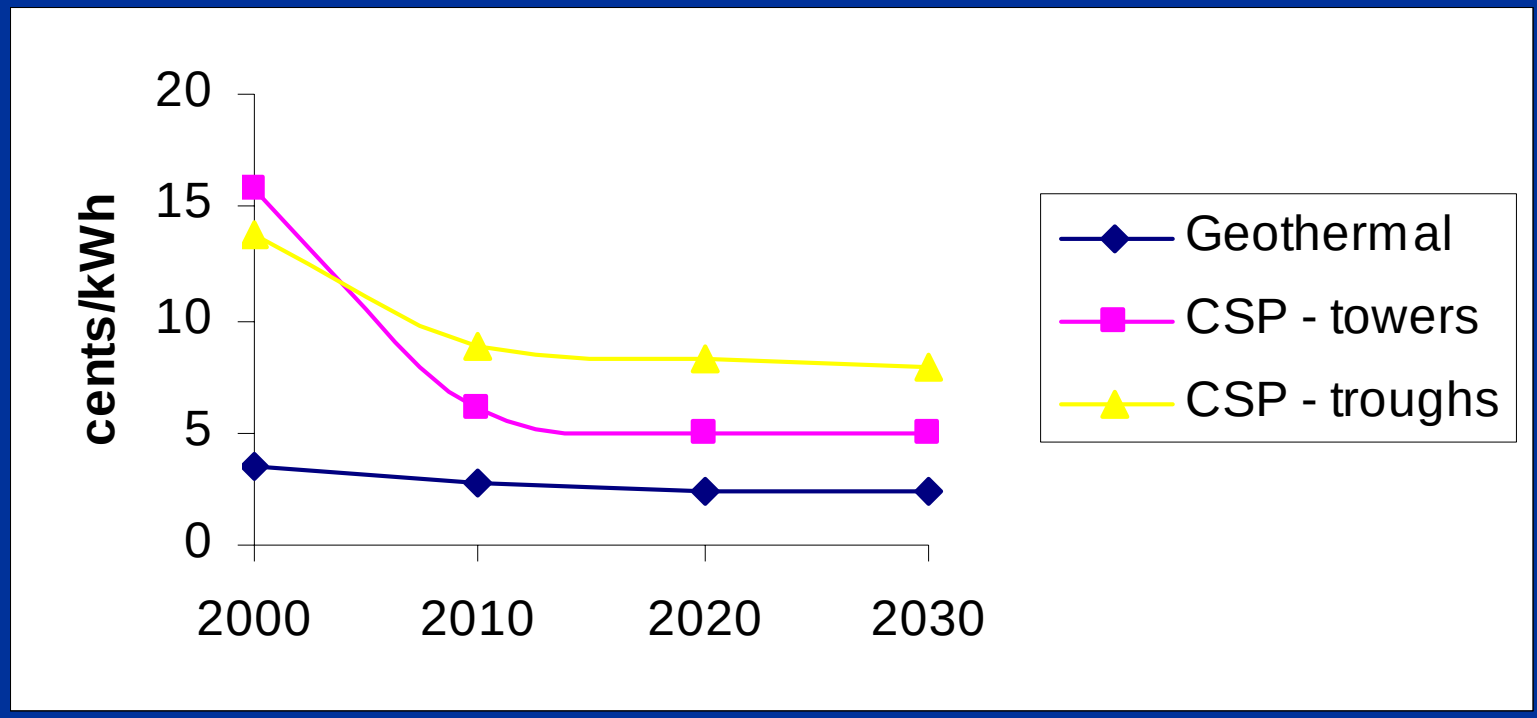
World PV Cell/Module Production (1988-2001) (in Megawatts)



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Rest of World	3	4	4.7	5	4.6	4.4	5.6	6.35	9.75	9.4	18.7	20.5	23.42	32.6
Europe	6.7	7.9	10.2	13.4	16.4	16.55	21.7	20.1	18.8	30.4	33.5	40	60.66	86.38
Japan	12.8	14.2	16.8	19.9	18.8	16.7	16.5	16.4	21.2	35	49	80	128.6	171.22
United States	11.1	14.1	14.8	17.1	18.1	22.44	25.64	34.75	38.85	51	53.7	60.8	74.97	100.3
Total	33.6	40.2	46.5	55.4	57.9	60.09	69.44	77.6	88.6	125.8	154.9	201.3	287.65	390.5

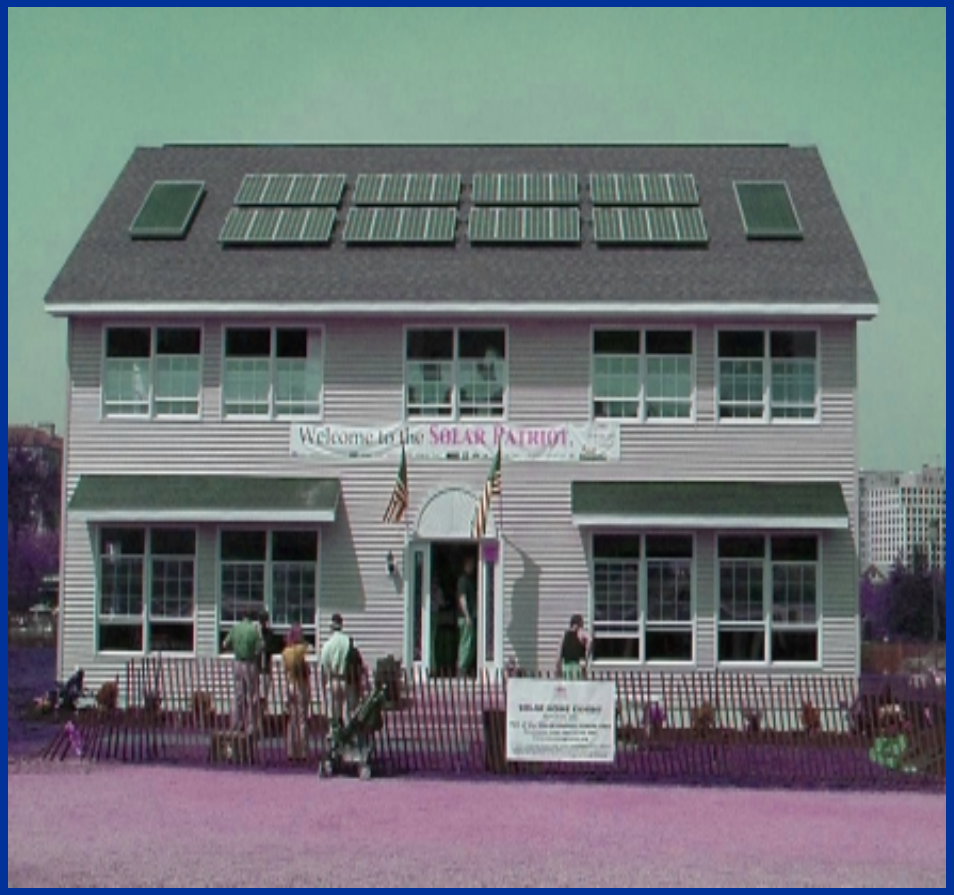
From PV News, Paul Maycock, editor; yearly February editions.

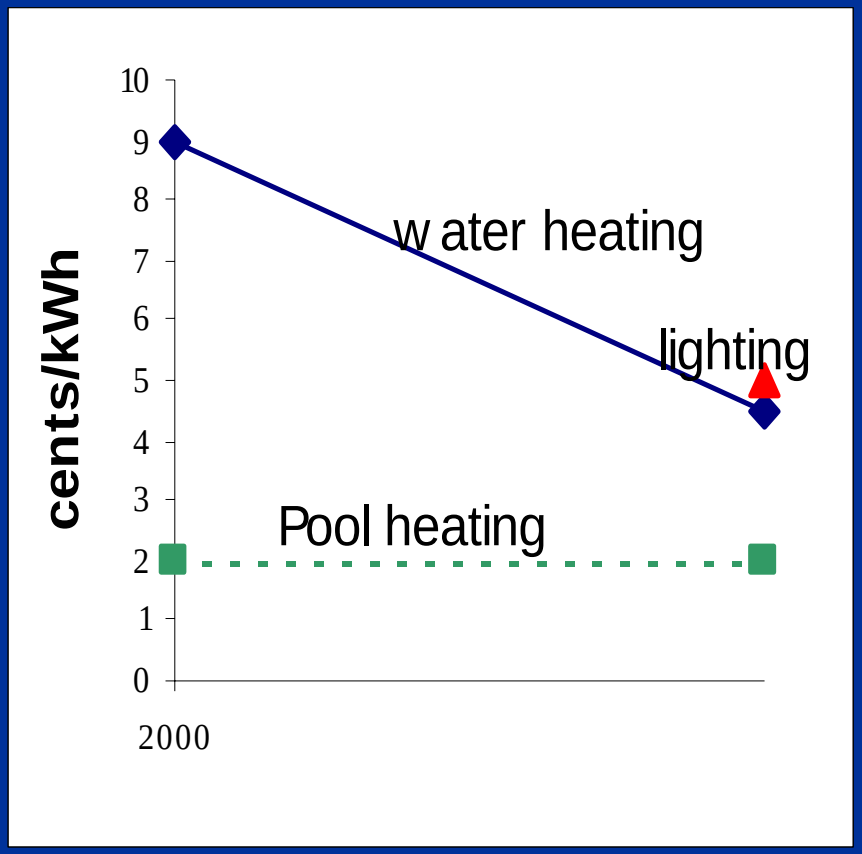
Other Renewable Electric Technologies



Source: http://www.eren.doe.gov/power/techchar.html

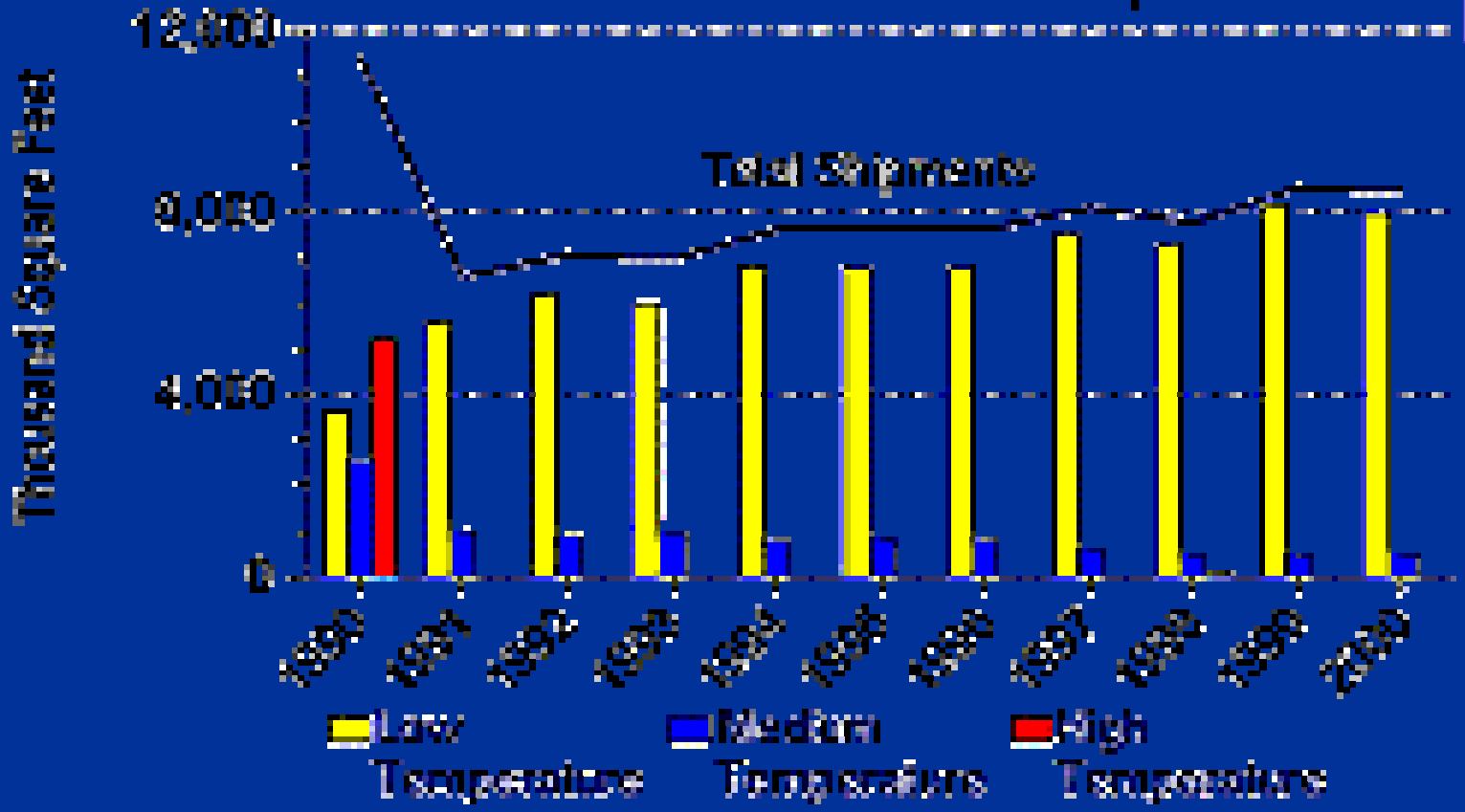
Solar Buildings





Source:

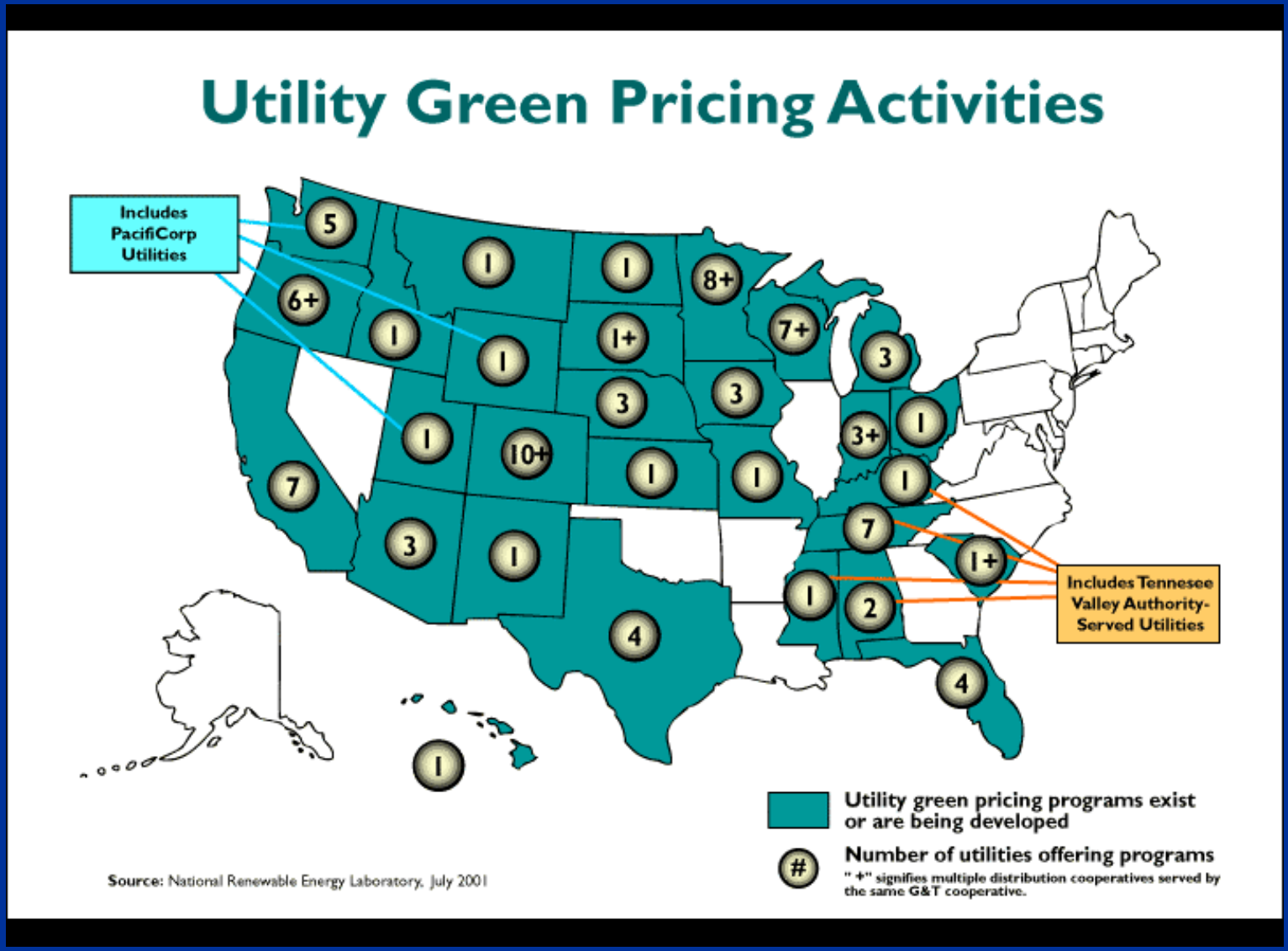
Solar Thermal U.S. Shipments



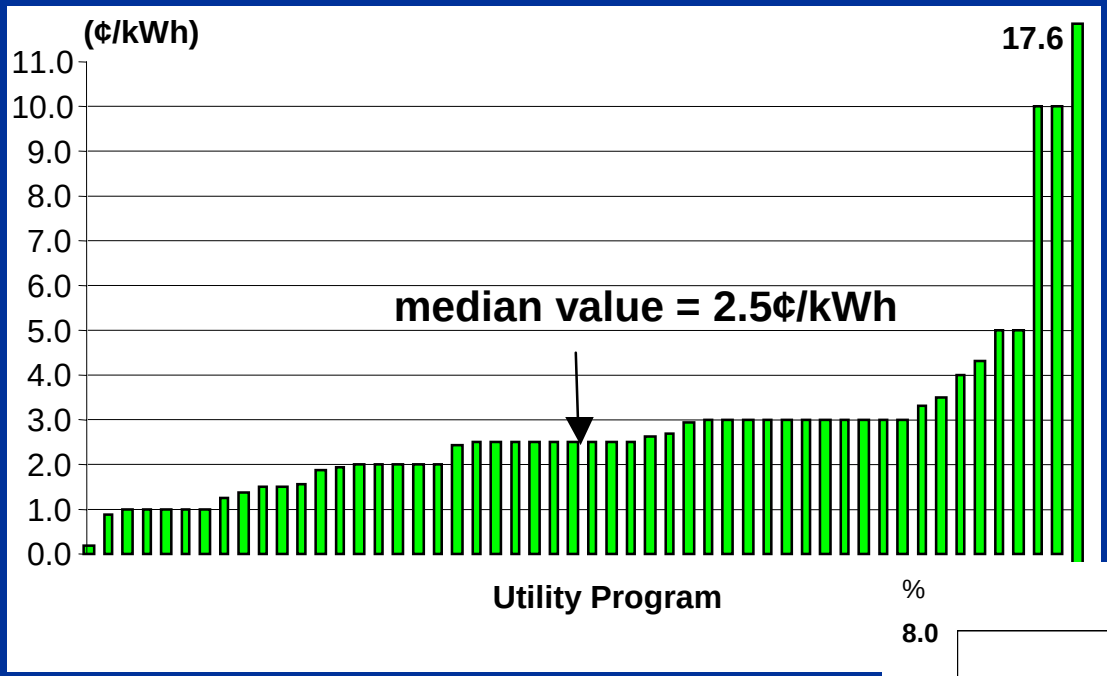
- 26 U.S. companies actively producing solar collectors with 10 companies supplying 97%
- Almost all companies in CA, FL, HI, NY, NY, TX

Source: http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/chapter2.html#solar

U.S. Green Pricing Programs

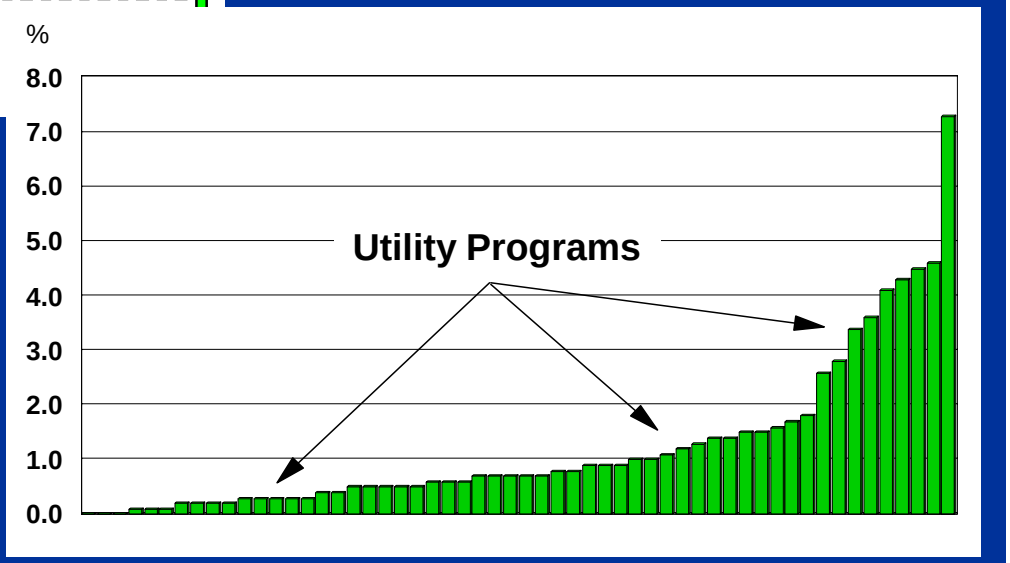


Green Power Program Assessment



Statistics for Utility Green Pricing Programs

Participation Rates for Utility Green Pricing Programs



Green Power Market Development Group

- **Goal**
  - **Procure 1,000 MW of new, cost-competitive green energy capacity by 2010.**
    - ***equivalent to about 7% of the group's collective energy demand***

Alcoa
Cargill Dow
Delphi Automotive
DuPont
General Motors
Kinkos
IBM
Interface
Johnson & Johnson
Pitney Bowes

Data Sources

- Technological Progress
  Cost/performance Improvements
  - EPRI/DOE 1997 *Renewable Energy Technology Characterizations* (Electric)
    http://www.eren.doe.gov/power/techchar.html
  - EPRI 2001 *Renewable Energy Technical Assessment Guide* (Electric) proprietary
  - DOE/EIA *Annual Energy Outlook 2002*
    http://www.eia.doe.gov/oiaf/aeo/assumption/index.html

Data Sources (Cont'd)

Installed Renewable Electric Capacity

- **DOE/NREL Renewable Electric Plant Information System (REPiS)**
  - http://www.eren.doe.gov/repis/
  - ownership, location, operational status, and nameplate capacity of all RE power plants
- **EIA - all plant types above 1 MW**
  - http://www.eia.doe.gov/cneaf/electricity/epav1/elecprod.html#tab2
- **EPA Emissions & Generation Resource Integrated Database (EGRID)**
  - http://www.epa.gov/airmarkets/egrid/
  - NO_X, SO_2, CO_2, and Hg emissions by plant
- **American Wind Energy Association**
  - http://www.awea.org/projects/index.html

Renewable Power Plant Capacity

Technology	Cumulative Capacity MW	Data Year	Data Source
Geothermal	2769	2000	REPiS
Photovoltaic	26.63	2000	REPiS
Solar Therma	354	2000	REPiS
Wind	4261	2001	AWEA
Biomass	11,752	1999	REPiS
Hydro	75,090	1999	REPiS

Data Sources (Cont'd)
General

- Energy Efficiency and Renewable Energy Network
  - http://www.eren.doe.gov/
- National Renewable Energy Laboratory
  - http://www.nrel.gov/
- Renewable Energy Industry Associations
  - AWEA, SEIA, GEA, GRC, ABA